designed and made of special material. The use of nickel steel has enabled us to make the long cranks of ample strength, although they weigh very little more than short ones. The strains introduced into the frame are mainly those due to chain pressure, and are not influenced by crank length but entirely by the speed of the chain. The speed of the chain can be increased by enlarging both the sprocket and back pinion wheels. Summarising our results it appears—

(1) That when we talk of designing the cycle to suit any individual rider, so as to develop his powers as a motor to the greatest extent, we have first to consider how we can best economise his nerve waste by enabling him to reduce the number of revolutions and increase the stroke through which his legs can travel. Our experiments have shown us that these conditions are best fulfilled in the great majority of cases by giving to the rider a length of crank equal to half the length of his thigh bone.

(2) That the value of M the multiple, in other words the gear, is then to be determined by the maximum strains which his muscles will stand, and we believe in most cases this corresponds to a pedal pressure F not exceeding 100 lbs. for weak individuals up to 140 lbs. for strong ones.

(3) That the crank length determines the shape of the frame and the length of the wheel base, and that the extra long wheel base necessitated by the long cranks renders the cycle pleasanter to ride and does not materially increase its weight.

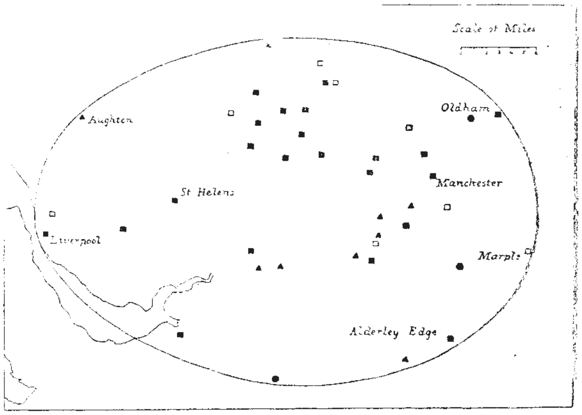
(4) That considering how important it is to reduce the number of crank revolutions in order to economise nerve waste, the cultivation of the pull stroke enables a greater average F to be obtained without straining the muscles beyond their elastic limit, and, consequently, allows of a higher multiple M and a correspondingly reduced number of revolutions. Out of a number of carefully made test runs we have selected the following as representative of the increased efficiency which we have obtained from the use of the lengthened cranks. The elder of us, aged 54, height 5 feet 10 inches, thigh bone 18-inch shank, from knee to ball of foot 21 inches, made a trial in the summer of 1896 with a cycle having 6½-inch cranks, geared to 99½. The total weight of rider and cycle was then 195 lbs., and the surface exposed to the air, including cycle, was 5½ square feet. The maximum distance that could be travelled on a good road with an average wind was 78 miles in ten hours, including rests, or in an actual riding time of 7¼ hours. The average foot pounds per minute in this case was 2917. In September 1898 R. E. Crompton made a test on a cycle having cranks 9·1 inches long, geared to 102. The weight of the cycle and rider was, as in the former trial, made up to 195 lbs. The test run was from Kensington Court, London, to Romsey in the New Forest and back; total distance 156 miles, total time 13 hours 28 minutes, riding time 10 hours 54 minutes. The bodily fatigue on this day was no greater than on the 78-mile run in 1896. In this ride the average foot pounds per minute throughout the day was 6650, so that whereas with the old system of short cranks in 1896, R. E. Crompton was able to maintain P at 2917 for 7¼ hours, with the new system in 1898 he was able to maintain 6650 for 10 hours 54 minutes; in other words, from a given amount of food or, what is the same thing, a given amount of bodily fatigue, R. E. Crompton was in 1898, on the long-crank machine, able to do three times as much work as he did on the short-crank machine in 1896. Many other similar runs have been made, and other long-crank riders can produce equally satisfactory results.

The theory we have formed as to the nature of bodily fatigue induced by cycle riding, in which we have endeavoured to show the extreme importance of the part played by the brain and nerve systems, and that probably the major portion of the energy of the human body considered as a motor passes through the brain and nerve tissues to energise the muscles, is a matter which merits the careful attention of physiologists. Writers on this subject have hitherto considered the human or animal motor as a heat engine, all the useful energy being obtained by corresponding chemical work done on the muscles. We believe that the greater part of the energy-yielding processes goes on within the brain itself or in the nervous system directly connected with the brain. Many facts observed by cyclists and other athletes when carrying out feats of endurance show that brain and nerve nourishment is to be aimed at rather than the repair of muscle waste, and that certain foods and drinks have to be avoided on account of their action in producing temporary slackness; in fact, on account of their preventing the brain from effectively energising the muscles.

## *NOTE ON THE DISTANCES TO WHICH EXPLOSIONS ARE FELT AND HEARD.*

ST. HELENS being situated in a thickly populated district, the disaster at Messrs. Kurtz's works (belonging to the United Alkali Company) seemed to offer a good opportunity for determining how far a great explosion may be felt and heard. Isolated observations, as will be seen below, have been made on other occasions; but, to feel confidence in the results, we require a fairly continuous series of records extending from near the centre of disturbance to the boundary of the affected area. I therefore wrote letters to all the more important newspapers in the south of Lancashire and north of Cheshire, in request of observations either of the sound or of the movement of windows by the air-waves. In reply to them, I received more than fifty accounts, which, in addition to several which appeared in the local press, gave a total of 61 records from 47 different places.

The immediate cause of the explosion was the firing of one of the vessels used in crystallising the chlorate of potash, the vessels being made of wood lined with lead. It is computed that eighty tons of chlorate exploded. The whole of Messrs. Kurtz's buildings were razed to the ground, and nine out of ten great vitriol chambers on the other side of an adjoining road were destroyed. Within a few hundred yards of the chemical works there are many streets of workmen's cottages; the doors, windows, chimney-stacks of whole rows were dismantled, and, in some cases, the roofs fell in. Within a radius of a mile or so, hardly a window seems to have escaped;[1] but according to one of my correspondents, who was in the north-west of the town, the damage to windows around him was comparatively slight.



On the accompanying map are shown all the places from which records of the explosion were obtained. A small square denotes a place where the air-wave was strong enough to make windows and doors rattle; if the square is filled in, the sound was also heard. Places where the observation of the sound only is recorded are represented by a circle if the observer was out of doors at the time, and by a triangle if he was inside, or probably inside, a house. A perceptible tremor of the ground, strong enough to be mistaken for an earthquake, was felt at some distance from St. Helens, but how far cannot be definitely ascertained.

It will be seen that the area over which the sound was heard is practically the same as that in which the air-wave was strong enough to make windows rattle. The bounding curve is elliptical in form, 39½ miles in length from east to west, 27¼ miles in breadth, and includes an area of about 850 square miles. St. Helens lies close to the longer axis of the curve and nine miles to the west of the centre. Towards the east, the sound was heard at Alderley Edge (24½ miles from St. Helens) and at Oldham (27 miles). Windows were observed to rattle at Alderley Edge and also at Marple (28 miles). To the west of St. Helens the sound was heard at Liverpool (10 miles) and Aughton (10 miles). I have tried in vain to ascertain the direction of the wind at the time of the explosion at different places

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[1] The above particulars are obtained from the account given in the *Manchester Guardian* for May 13.

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within the sound-area, but the observation above recorded from the north-west quarter of St. Helens is worthy of notice in connection with the easterly elongation of the area of disturbance.

For the sake of comparison it may be worth while to refer briefly to the results obtained from previous explosions. At the conclusion of Sir John Moore's retreat, a great Spanish powder magazine, containing, it is said, 1500 barrels, was blown up near Corunna. The ground rocked sensibly for miles, and at a distance the shock was felt before the sound was heard (R. Mallet, *Irish Acad. Trans.*, vol. xxi., 1848, pp. 63-64). In the great Erith explosion (October 1, 1864) two barges, a large magazine and a small one blew up in succession. They contained respectively about 9, 33, and 4 tons of gunpowder. Everything within a distance of half a mile—trees, houses, barns —was utterly destroyed, except two haystacks on the south side of the river. Windows were shattered within a radius of at least five miles. The explosion was heard and felt at Teddington (21 miles), Uxbridge (27 miles), and Windsor (32 miles), and the concussion is said to have been felt near Ashford, which is distant about 40 miles (*Times*, October 3-6, 8, 1864). The catastrophe in the Regent's Canal (October 2, 1874) was caused by the explosion of about five tons of gunpowder. The shock and sound were observed as far as Chiselhurst (13 miles), and the vibrations were felt at Aveley (18 miles) and Gravesend (23 miles) (*Times*, October 3, 5, 1874). To effect the removal of the Flood Rock in Hell Gate, New York Harbour, about 130 tons of dynamite, &c., were exploded; and the vibrations were perceived, with the aid of a mercury bath and telescope, at a distance of 183 miles (*Times*, October 12, 1885; Milne's "Seismology," pp. 98-99). Mr. Fox Strangways states that the blasting operations in the Charnwood Forest quarries can be heard at a distance of 18 miles or more (NATURE, vol. liii., 1895, p. 130). The shock caused by the explosion of nearly 50 tons of dynamite at Johannesburg on February 19, 1896, was felt at Krugersdorp (19 miles) and Pretoria (33 miles) (*Standard*, February 21, 22, 1896). The Lagouban naval magazine (near Toulon), which blew up on March 5, 1899, is said to have contained 50,000 kg. of black powder. The country for a radius of nearly two miles was swept almost bare. Houses were razed to the ground, and trees were overturned or bent into the most extraordinary shapes. It is affirmed that the report of the explosion was heard at Nice (84 miles), and even beyond the frontier at Ventimiglia (100 miles); but it is obvious that, in the absence of intermediate records, we cannot place much reliance on these accounts (*Times*, *Daily Chronicle*, *Daily Mail*, *Daily Telegraph*, March 6, 1899).

CHARLES DAVISON.

## THE HURTER MEMORIAL LECTURE.

THE memorial lecture established by the Liverpool Section of the Society of Chemical Industry in memory of Dr. Ferdinand Hurter, and which will be given every alternate year, was inaugurated by Prof. G. Lunge, of Zürich, on October 4, before a large and representative gathering at University College, Liverpool. Prof. Lunge's subject was "Impending changes in the general development of industry, and particularly in the alkali industries." After an appreciative review of Hurter's contributions to technical chemistry, in which special reference was made to his remarkable mathematical power and to the manner in which he employed it side by side with the highest branches of chemical science for the investigation and elucidation of technical problems, Prof. Lunge turned to the more immediate subject of his address. In contemplating the general features of chemical industries as carried on to-day, the question of the supply of fuel and of other sources of power was first considered; it was pointed out that the superiority which many countries, notably Great Britain, enjoy in many industries on account of their wealth of coal is limited in time, and that the increasing consumption of coal with a decreased source of supply as the result, must lead to the employment of other sources of energy. The economical use of coal in the blast-furnace, the adoption of closed coke ovens which, in addition to allowing the recovery of by-products, also increase the yield of coke, and recent improvements in the production of gaseous fuel are likely to postpone the time and force of the competition of those other sources of energy of which water-power stands foremost, but such postponement is restricted essentially to certain industries. From a general standpoint the total energy of the fossil fuel of the world is an infinitesimal fraction of the energy which the sun expends daily on the evaporation of water, and which is transformed to a great extent into the kinetic energy of falling water. The transformation of water-power into electrical energy, with its easy and cheap power of transmission, is likely to lead to revolutionary changes in chemical industries, not only in respect to the conditions of manufacture, but also in regard to the centres of production. Countries possessing great water-power will in the future carry on all those manufacturing processes in which electricity is either essential or an advantage, subject to certain limitations regulated by the cost of carriage of both raw materials and products. Prof. Lunge detailed the present position of electrical processes applied to chemical industries, dealing especially with the alkali trade and the manufacture of bleach and chlorate; the next generation will in all probability, in his opinion, obtain its chlorine by electrolytic methods, but the accompanying alkali will not form more than one-eighth or one-tenth of the world's demands The bulk of the latter must therefore be derived from other sources—these, in Dr. Lunge's opinion, will be the ammonia-soda process and naturally occurring soda. In regarding the future of these industries the modern developments of the manufacture of sulphuric acid by the catalytic process, in which sulphur dioxide and oxygen are passed over platinised asbestos, were discussed; the success of this method, especially for the manufacture of strong acid, is thoroughly established, and the lead chamber is threatened with extinction in consequence. Prof. Lunge pointed out, however, that this old apparatus has still certain claims of efficiency in the manufacture of weak sulphuric acid. Incidentally, in considering the economical use of fuel, Prof. Lunge gave a most interesting description of the Dellwik-Fleischer water-gas process, the efficiency of which he had himself examined with the result that he found that it gave no less than 82 per cent. of the fuel value of the coke against the 45 per cent. of the older processes. The characteristic of the process is the formation of carbon dioxide during the "blow" instead of carbon monoxide, a fact which reduces the time of the blow from 10 minutes to 1¾ minutes.

In looking back upon the industry with which Hurter's life-work was associated, Prof. Lunge dwelt upon the fact that the very processes Hurter had helped so ably and successfully were without doubt doomed, if not to complete extinction, still to a most serious crippling. Like other earnest workers, Hurter had but tilled the soil from which others will reap a harvest; and although there is a feeling of sorrow in the thought that so much genius, inventive talent and honest labour had been expended in what seemed now a transient aim, still

> Der wer den Besten seiner Zeit genug gethan
> Der hat gelebt für alle Zeiten.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. A. Hutchinson, of Pembroke College, has been reappointed Demonstrator in Mineralogy and Assistant-Curator of the Museum of Mineralogy for a term of five years.

Sir Walter Gilbey and Mr. Austin Keen have been appointed additional members of the Board of Agricultural Studies.

Mr. H. Woods, of St. John's College, is to be appointed a University lecturer in Palæozoology. He has hitherto held the post of demonstrator in this subject at the Woodwardian Museum.

The awards of entrance scholarships have been made at the two groups of Colleges, the first comprising Trinity, Clare and Trinity Hall, the second Pembroke, Caius, King's, Jesus, Christ's, St. John's and Emmanuel. One hundred and seventeen scholarships and exhibitions have been given; of these 23 are for mathematics, 28 for natural science, and 49 for classics. The value of these scholarships varies from 80*l*. to 40*l*. a year, that of the exhibitions from 50*l*. to 20*l*. a year.

NEGOTIATIONS have been proceeding with the authorities of Mason College and King Edward's Foundation relative to the provision of a remodelled system of commercial education in Birmingham. It is expected that the charter of the new University for Birmingham will be granted early next year, and that there will be a faculty of commerce in connection therewith.

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